TITLE OF THE INVENTION

Velimir M. Stanimirovic, PE; Citizen of U.S.A.
Residence: 415-76th Street, Apt.-8
Miami Beach, Fl. 33141

Energy Conservation Flywheel with Variable Moment of Inertia (ECF-VMI)

CROSS-REFERENCE TO RELATED APPLICATIONS

U.S. Patent Documents

3248967	May 1966	Lewis Oliver G.
3897692	August 1975	Lehberger, Arthur N.
4406584	September 1983	Stepp, William J.
4579011	April 1986	Dobos, Elmer M.
4730154	March 1988	Pinson, George T.
4926107	May 1990	Pinson, George T.
5269197	December 1993	Yang, Tai-Her
6694844	February 2004	Love, Ralph E.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT.

Not Applicable

THE NAMES OF THE PARTIES TO A JOINT RESEARCH AGREEMENT

Not Applicable

INCORPORATION-BY-REFERENCE OF MATERIAL SUBMITTED ON A COMPACT DISC

Not Applicable

BACKGROUND OF THE INVENTION

Field of the Invention:

Flywheels are devices used in many machines to store kinetic energy (moment of inertia) during normal operation and deliver it when a higher moment of inertia is required. For example, flywheels are also used to increase the moment of inertia in automotive engines to smooth out revolutions. Some flywheels are used to store kinetic energy during engine or generator idle operation and use it when demand arises. Since stored flywheel energy depends on mass and revolution (moment of inertia), attempts have been made to devise a flywheel from new materials which would run at very high revolutions. Other attempts have been made to create flywheels and mechanical devices with variable moment of inertia so stored kinetic energy would be recovered through cycling for a longer period of time.

Background Art:

Not Applicable

BRIEF SUMMARY OF INVENTION

A kinetic energy storage device, an energy conservation flywheel with variable moment of inertia is proposed. From a central disk, sliding rods with mass weights attached to one end slide outward and inward from the center of the disk radially during rotation, hence creating variable moment of inertia. Sliding outward of rods/weights is caused by centrifugal forces. Sliding inward is achieved by a calibrated spring which is attached to other end of sliding rods, incurring centripetal forces as well. This device rotates in a horizontal plane.

The energy conservation flywheel with variable moment of inertia (ECF-VMI) uses Variable moment of inertia to store kinetic energy more effectively and for a longer period of time. Efficiency may be further improved by placing this device in a vacuum canister and adding magnetic bearings.

The “ECF-VMI” can be coupled with an electric generator in order to take over surplus energy from a driving machine, when there is a low energy demand, and use it during hours of peak demand.

Allowing great flexibility, the “ECF-VMI” device can be proportionally expanded and designed to be any desired and/or required size.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Sheet 1 Is In Perspective View.

Sheet 2, Figure A1 Is In Perspective View.

Sheet 3, Figure B1 Is An Elevation View (Vertical Plane).

Sheet 4, Figure B2 Is A Top View At Section A-A (Horizontal Plane).

Sheet 5, Names of Parts (Components)

DETAILED DESCRIPTION OF INVENTION

1.0 The subject of this patent application is an energy conservation flywheel with variable moment of inertia (ECF-VMI). This apparatus is an assembly made up of three subassemblies of a steel frame (sf), namely, a flywheel (fw) and a steel spring (ssp).

1.1 Subassembly (sf) consists of the following components:

-Three rigid steel plates of rectangular shape bolted together with supporting legs and bolts to form a shelf like steel frame.

-Pre-lubricated, self-aligning machined ball bearings with pillow blocks, square flange mount. These are fastened with bolts to a steel frame.

-A revolving spring linkage made up of a bottom part machine ball bearing - axially loaded (screwed to a steel frame), tension bolt and nut with its top fitted with a linkage or coupling for a spring.

1.2 Subassembly (fw-top shape) consists of the following components:

-A wheel/disk made of steel plate with four square openings near a disk center and four (fine surface) holes drilled from its circumference to the square openings toward the center of the disk (90 deg. apart). From the square openings, there are four additional smaller holes running toward the disk/shaft center.

-A hollow shaft of a hollow, cylindrical shape and of steel construction, having four small holes (90 deg. apart) on a fine surface.

-A shaft collar of a hollow, cylindrical shape, cut along cylinder height and with a set screw.

-A wheel/disk and a hollow shaft joined together under compression thus making one integral part.

-Steel spheres are of steel construction and each one has a treaded hole in it.

-Pistons/rods are of cylindrical shape and steel construction with fine surfaces. Each piston/rod has one end treaded, has a stopping pin at the other end and also has a hole run axially with a set screw perpendicular to it.

1.3 Subassembly (ssp) consists of the following components:

-A calibrated extension spring.

- Four pieces of stainless steel cable (wire rope) and a wire rope clip.

- Tension bolt and nut/revolving spring linkage.

Description of Operation of the Energy Conservation Flywheel with Variable Moment Of Inertia Model "ECF-VMI-01" (Shown on Drawings) and is in Production:

"ECF-VMI-01" will start to rotate after it receives initial spin, thru a flexible coupling and/or a detachable clutch (fc/dc), from any driving device. This driving device will be turned off and/or detached so then the sum of moments of external forces about the axis is zero. Let the initial (or point #1) spin be 52 rad/s (496 rpm), then mass moment of inertia will be 0.2116 (slug-ft^2), centrifugal forces created by rotation and acting on spheres (ss/r) will be 750.4 lbs at this point.

This will cause steel spheres/rods (ss/r) to start moving outward, mass moment of inertia will start increasing (at final or point #2 will be 0.3208 slug-ft^2), rotation/centrifugal forces will be decreasing (34.3 rad/s or 327 rpm at point#2); kinetic energy will be decreasing also. At point #2 centrifugal forces (431.2 lbs) will become equal to the steel spring (ssp) force (431.2 lbs) stretched for a lent of the spheres/rods (ss/r) travel.

Therefore centrifugal forces and a spring force will be in balance. Further rotation decreasing (so centrifugal forces) will cause spheres (ss/r) to start retracting under the spring (ssp) force. When this happen, rotation will start to increase (conservation of angular momentum) hence centrifugal forces will increase (kinetic energy too) also; (ss/r) will be moving outward until centrifugal forces become equal to the spring (ssp) force. Again, when rotation starts to decrease centrifugal forces will start to decrease hence the spring (ssp) will start to retract steel spheres (ss/r) in and thus mass moment of inertia will decrease but rotation will start increasing (conservation of angular momentum). Increased rotation will cause increase of centrifugal forces (also kinetic energy); the steal spheres (ss/r) will start moving outward and so on process will continue to cycle.

Now driven device can be turned or coupled on in order to use "ECF-VMI-01" stored kinetic energy.

This device rotates in horizontal plane.

Friction loses are neglected in the above explanation.

Sample Calculation of the Above Description of ECF-VMI-01:

Steel Sphere (ss):

Diameter D=3"; Radius r=1.5"; Steel density δ=490 lbs/ft^3

Sphere volume $V= 4/3\pi r^3 = 4/3x\ \pi\ x\ 1.5^3 = 14.14\ in^3 = 0.0082\ ft^3$

Sphere weight $w = V\delta = 0.0082\ x\ 490 = 4.0$ lbs

Sphere mass $m = w/g = 4.0/32.2 = 0.124$ slugs, where

$g = 32.2$ ft/s^2; slug = (lbs s^2 /ft)

Mass moment of inertia of 'ss'

$Io = 2/5mr^2$ (slug-ft^2) centroidal; $Io = 2/5 \times 0.124 \times (1.5/12)^2 = 0.000775$ (slug-ft^2)

Sphere is 6.5" away from axis initially, and then mass moment of inertia about axis (z) is,

$Izi = Io + mxi^2 = 0.000775 + 0.124 \times (6.5/12)^2 = 0.0372$ (slug-ft^2)

Sphere is moving outward, farthest from axis (z) is 8.5", and then mass moment of inertia is,

$Izf = Io + mxf^2 = 0.000775 + 0.124 \times (8.5/12)^2 = 0.063$ (slug-ft^2)

There are 4 spheres, therefore

$Izi\ (4) = 4 \times 0.0372 = 0.149$ (slug-ft^2)

$Izf\ (4) = 4 \times 0.063 = 0.252$ (slug-ft^2)

Wheel/Disk (w/d):

Diameter D =10"; Radius r = 5"; Thickness t = 1"

Solid disk volume: $V = r^2 \pi t$ (ft^3); $V = (5/12)^2 \times \pi \times (1/12) = 0.04545$ (ft^3)

Weight of solid disk: $W = V \delta = 0.04545 \times 490 = 22.27$ (lbs)

Mass of solid disk: $m = W/g = 22.27 / 32.3 = 0.692$ (slug)

Mass moment of inertia of solid disk: $Iy = Iz = ½\, m\, r^2 = ½ \times 0.692 \times (5/12)^2 = 0.06$ (slug-ft^2)

Square (or oval) openings

a = 1"; t = 1"; $W = V \delta = (1/12)^2 \times (1/12)^2 \times 490 = 0.284$ (lbs); Mass, $m = 0.284/32.2 = 0.0088$ (slug)

This opening is a negative weight (only air is there)! Also it is made slightly oval at corners but that is negligible!

Mass moment of inertia-centroidal, $Iyo_1 = 1/6\, m\, a^2 = 1/6 \times 0.0088 \times (1/12)^2 = 0.00001$ (slug-ft^2)

6/12

Mass moment of inertia with respect to 'z' (FW) axis, $Izo_1 = Iy_1 + m(1.25/12)^2 =$ $0.00001 + 0.0088 \times x (1.25/12)^2 = 0.000106$ (slug-ft²)

Then 4 openings have negative mass moment of inertia, $Izo = 4 \times 0.000106 =$ 0.00042 (slug-ft²)

Wheel/Disk with 4 openings has mass moment of inertia,

$Id = Iz - Izo = 0.06 - 0.00042 = 0.0596$ (slug-ft²)

Piston/Steel (p/s), Slender Rod:

Diameter, d = 0.5"; r = 0.25"; Length, l = 4"; Actual is 5" but 1" of it is treaded and screwed into a sphere therefore only 4" length is used to calculate this rod mass moment of inertia.

Weight, $W = r^2\pi l\delta = 0.25^2 \times \pi \times (4/12) \times 490 = 0.223$ (lbs); Mass m (rod) = W/g = $0.223/32.2 = 0.0069$ (slug)

$Iyp_1 = ½m (3r^2 + l^2) = ½ \times 0.0069 \times (3 \times 0.25/12 + 4^2/12^2) = 0.0006$ (slug-ft²)

Rod center is 3" from axis 'z' initially, then;

$Iyi = Iyp_1 + m (3/12)^2 = 0.0006 + 0.0069 \times (3/12)^2 = 0.00103$ (slug-ft²)

The rod is moving outward, during rotation, to 5" final from 'z' axis (there is a stop pin), then

$Iyf = Iyp_1 + m (5/12)^2 = 0.0006 + 0.0069 \times (5/12)^2 = 0.0018$ (slug-ft²)

There are 4 rods.

Initial centroid of the Sphere/Rod (s/r) Assembly (From 'z' axis);

$x_1 = (0.124 \times 6.5" + 0.0069 \times 3")/ (0.124 + 0.0069) = 6.32" = 0.53$ ft.

Sphere/Rod assembly mass moment of inertia; $Is/r = Io + Iy_1 = 0.000775 + 0.0006 =$ 0.00137 (slug-ft²)

Initial Mass Moment Of Inertia Of S/R (Point-1);

$Is/ri = Is/r + (mo + mr) x_1^2 = 0.00137 + (0.124 + 0.0069) \times 0.53^2 = 0.038$ (slug-ft²)

For 4 s/r; $Is/ri = 4 \times 0.038 = 0.152$ (slug-ft²)

7/12

Final Mass Moment Of Inertia Of S/R (Point-2);

S/R Assembly is moving outward to final (Point-2) position;

Final centroid of S/R Assembly from 'z' axis; x2 = 0.53' + (2"/12)' = 0.7 ft.

Then final (Point-2) s/r mass moment of inertia;

$I_{s/rf}$ = Is/r + (mo + mr) x_2^2 =0.00137 + (0.124 + 0.0069) x 0.7^2 = 0.0655 (slug-ft^2)

For 4-S/R; Is/rf = 4 x 0.0655 = 0.262 (slug-ft^2)

Initial mass moment of inertia of 'FW' (Point-1):

I_i = Is/r_i + Id = 0.152 + 0.0596 = 0.2116 (slug-ft^2)

Final mass moment of inertia of 'FW' (Point-2):

I_f= Is/r_f+ Id = 0.262 + 0.0596 = 0.3216 (slug-ft^2)

Energy Conservation

After initial spin no external moments act on the system (fw) hence there is conservation of angular momentum, and then

$I_i \times \omega_i = I_f \times \omega_f$

Initial angular momentum (Point-1) when 'fw' rotates at 52 (rad/sec) or 496 rpm is Ii x ω_i = 0.2116 x 52 = 11.0 (lbs-s-ft)

Then from final angular momentum (Point-2), $\omega_f = I_i \times \omega_i / I_f$ = 11.0 / 0.3216 = 34.2 (rad/sec) or 327 rpm.

Centrifugal Forces

$\Sigma Fn = ma_n$ (lbs); $a_n = \check{r}\omega^2$

One sphere/rod assembly: Fs/r = $ma_n = m\check{r}\omega^2$ (lbs),

where $m=m_s + m_r$ = 0.124 + 0.0069 = 0.1309 slug.

At point #1 (Initial); rl = 0.53Ft & ω_i = 52 (rad/s) then, Fs/r_i = 0.1309 x 0.53 x 52^2 = 187.6 (lbs),

For four assemblies: 750.4 (lbs)

8/12

At point #2 (Final); r2 = 0.7Ft & ωf = 34.2 (rad/s) then, Fs/rf = 0.1309 x 0.7 x 34.2^2 = 107.2 (lbs),

For four assemblies: 428.8 (lbs)

These forces will transfer vertically by steel cables to an extension spring.

Require an extension spring to balance out this force while extended 2".

Tangential Forces

$\Sigma F_t = m\check{r}\alpha$

Only tangential forces acting on 'fw' are frictional in bearings and air friction. Being a complex calculation requiring much space, this is left out for now.

$\Sigma M_o = I_o\alpha$ (about mass center and axis 'z' of rotation.)

The flywheel rotates in a horizontal plane and, therefore, the g-force acts normally to the horizontal plane.

Kinetic Energy

At point#1, T1 = $\frac{1}{2} I_i \omega_i^2$ = ½x0.2116x52^2 = 286.1 (lbs-ft), stored energy initially.

At point#2, $T_2 = \frac{1}{2} I_f \omega_f^2$ = ½x0.3216x34.2^2 = 188.1 (lbs-ft), stored energy decreased.

At final point, spheres are farthest from 'z' axis since rotation decreased. The spheres retract because of decreased centrifugal forces. Thus starts the recovery of kinetic energy since rotation increases.